

Group Chairman's Factual Report

Engineering and Stability

M/V Lady D Capsizing

Accident Number: DCA-04-MM-015

Oct 07, 2005

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Figure 1 – Righting arm curves

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A. Accident Data

Accident No.: DCA04MM015
Vessel Involved: Small passenger vessel *M/V Lady D*
Location: Northwest Harbor, Baltimore, MD
Date: March 06, 2004
Time: 1600 EST¹

B. Engineering and Stability Group Representatives

1) National Transportation Safety Board

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3) Party: Seaport Taxi

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¹ All times are in Eastern Standard Time as read on a 24-hour clock, unless specifically noted.

4) Party: Baltimore City Fire Department

No representative on group

5) Party: Susquehanna Santee Boatworks

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6) Party: National Weather Service

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C. Summary



The small passenger vessel *Lady D*, operated by Seaport Taxi, was placed into routine service for the day at 1100 on the day of the accident (March 06). Its scheduled route for the day was from Fells Point to Fort McHenry, and then back to Fells Point, with a round trip time of 30 to 35 minutes. The *Lady D* was operated on this schedule throughout the day, until the time of the accident. With a crew of two and no passengers aboard, the *Lady D* arrived at Fort McHenry fire boat pier 1 about 1545. As no passengers were

disembarked at the dock upon arrival, the fort coordinator directed about 18 waiting passengers to board the *Lady D*. Subsequently, four additional passengers boarded, and the *Lady D* departed the fire boat pier.

Shortly after the *Lady D* departed Fort McHenry, the senior captain (on the water), who was operating another pontoon-type water taxi between Harbor Place and Fells Point, noticed the approach of bad weather. He reported to the company's other vessels by VHF radio that a squall was in the harbor and that boat operators should find the nearest safe place to wait for the storm to pass. The senior captain then called the master of the *Lady D* to see if he had left the Fort dock. The senior captain also recommended two safe locations for the captain of the *Lady D* to attempt a landing. The captain of the *Lady D* responded that he had already left Fort Mc Henry, and that diverting to a safe landing sounded like an excellent idea. The Office Manager of Seaport Taxi overheard the transmission and checked the National Weather Service's doppler weather image on her computer. She subsequently reported by VHF to the fleet that the heaviest concentrations of precipitation were to the north and south of downtown Baltimore, and that areas of blue and green precipitation were over the harbor. She also stated that it appeared as if the severest weather would not affect the harbor. Shortly afterward, the senior captain arrived at Fells Point and called the *Lady D* again, but the captain of *Lady D* did not respond. The senior captain then attempted to call the *Lady D* captain on the company UHF radio. He also attempted to call the cell phones of both the master and mate.

According to witness statements, the *Lady D* had backed away from the Fort pier and began its voyage to Fells Point. A heavy rain and windstorm began as the vessel departed from Fort McHenry. The intensity of the rain and wind was reportedly high and increasing. The passengers reported that the vessel began to roll in the waves. Some passengers reported that the wind was initially off the port bow of the *Lady D*, and that relative direction of the wind began to shift in counterclockwise direction. The intensity of the rolling increased until the vessel heeled to starboard dramatically causing some passengers to leave their seats and shift to the port side. The vessel's list to starboard decreased and the mate asked passengers to return to their seats. Some passengers recall the captain altering course to starboard. Moments later, the vessel dramatically heeled to starboard again, and continued over on to her starboard side, and then capsized. Some passengers estimated that the capsizing event took only a few seconds.

The crew did not instruct passengers to put on life preservers and no one put one on before the vessel capsized. The crew and most of the passengers were able to escape through the side windows to the surface.

About 1600, two persons from the Naval Reserve Center at Fort McHenry witnessed the accident and called 911. Shortly afterward, about 19 persons from the Naval Reserve Center boarded an idle navy mechanized landing craft (LCM-8 or "Mike Boat") moored at the Center's dock, and proceeded to the accident location to render assistance. The LCM was the first vessel to arrive at the scene to render assistance. Most of the passengers were transferred from the water to the LCM and transported back to shore by the crew of the LCM.

A marine firefighter (Marine Pilot) at the Baltimore City Fireboat Station witnessed the accident and alerted others at the fireboat station. A 30-foot fire rescue boat was dispatched to the scene to render assistance. The fire rescue boat was later joined by a Police Department vessel. According to preliminary information, three injured passengers were transported to shore by the fire rescue boat, and two passengers were transported to shore by the police boat.

About 1616, the Coast Guard heard of the accident by VHF channel 16 (they overheard chatter about the accident), and dispatched two SAR vessels (small boats) to the scene. Subsequently, the USCG dispatched two aircraft and a third SAR vessel to join in the SAR operation.

The operating company of the vessel, Seaport Taxi, sent its fleet captain and the senior captain to the area to assist. These persons, aboard another company vessel, without direction from the on scene commander, conducted surface searches of the area to the south (downstream) of the accident location.

All but three persons were accounted for within an hour of the accident. The three missing passengers were located and recovered from the bottom of the harbor one week after the accident. Of the twenty-two persons accounted for after the accident, one passenger died at the scene, a second passenger died within 72 hours, and a third passenger continues to be under long-term medical care. The remaining persons were treated by local hospitals for minor injuries and released.

After the capsizing and during the recovery operation, the vessel drifted downstream as a result of wind forces. About 1730, the vessel was taken under tow by a local commercial tow vessel and was towed to the fire boat pier near Ft. McHenry. The following day, the vessel was up righted through the use of a shoreside mobile crane, and was later towed to a local marina for safe keeping. The NTSB engineering group performed an out of water damage survey of the vessel on March 9, 2005, at the marina where it was being stowed.

According to media reports, in early November 2004, Living Classrooms, Seaport Taxi's parent company, entered into a partnership agreement with Ed Kane's Watertaxi Service, a competitor to Seaport Taxi. Living Classrooms ceased operating its fleet of nine vessels and began selling water taxi tickets at its National Historic Seaport kiosk locations for its former competitor's service.² In addition, Living Classrooms agreed to provide marketing and job training. Kane had no plans to buy the Seaport Taxi vessels, and according to the director of the National Historic Seaport of Baltimore, they will likely be sold to operators outside of the Baltimore area.

D. Details of the Investigation

1) Vessel Data

A. Accident Information

NTSB NO. DCA03MMA032

Date of Accident:

Saturday March 07, 2004

Time of Accident (local)

1600

Location

Northwest Harbor, Baltimore, MD

² Media report at WBAL.com, Nov 2, 2004, website
<http://www.thewbalchannel.com/travelgetaways/3884127/detail.html>

Type of Accident	Capsizing
Coastal/Ocean/Harbor/Pilotage	Harbor

B. General Information

Vessel Name	<i>M/V Lady D</i>
Vessel former name(s)	None
Flag	U.S.
Port of Registry	Not documented
Owner's Name	Baltimore Harbor Shuttle, LLC
Waters (Int'l or Inland):	Inland, protected river
Builder	Susquehanna Santee Boatworks
Location built	Willow Street, PA
Date keel laid	March 18, 1996
Date Launched	March 28, 1996
Official Number	MD8246BC

C. Vessel Particulars

Type of Vessel:	Pontoon, small passenger
Passengers on board	23
Max capacity, persons	25
Gross Tons	2
Length	36 ft
Beam	8 ft
Pontoons (2)	Circular cross section, aluminum construction, 2-ft diameter
Propulsion type	Single, 4-stroke outboard, gasoline fuel, 90 horsepower
Electrical Power	12 VDC, engine driven alternator and single battery

D. Crew

Number Total	2 (1 master required by COI, deckhand carried but not required)
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E. Vessel information

Fuel on Board (gasoline)	Approximately 30-gal
Fuel capacity	Approximately 40-gal
Cruising speed, approx (knots)	6
Max speed, approx (knots)	12

F. Machinery Information

Outboard motor	Manufacturer: Honda, 90-HP, 4-stroke
Steering system	Hydraulic pump at steering console connected by hoses to hydraulic cylinder actuators located near engine
Throttle/clutch control	Independent, 2 cable
Communication system	1 VHF radio, Standard Horizon Eclipse +, model GX1250SA, fitted with NOAA weather alert feature

2) Vessel history and description

- a) History. The *Lady D* was built in 1996 by Susquehanna Santee Boatworks of Willow Street, PA. It was the third in a series of four 36-ft long by 8-ft wide pontoon boats, three of which were constructed by Susquehanna Santee Boatworks. The first boat in the series was built in Baltimore by an individual in his backyard, and the subsequent 3 boats were built by Susquehanna Santee Boatworks. The four boats were built between 1986 and 1996. During its life, the *Lady D* was operated as a water taxi in Baltimore Harbor. Between March 1996 and March 2000 it was operated by Harbor Shuttle. In March 2000, Seaport Taxi purchased Harbor Shuttle's fleet of boats, and it came under their management until the time of the accident.
- b) Hull. The hull of *Lady D* was constructed of two cylindrical pontoons connected by an I-beam framework and deck structure. The pontoons were made of 24-inch diameter aluminum shape (.125 thick), and each of the two pontoons was built up from 7 sections. The five mid-sections were each 6-feet in length, and the sections at the bow and stern were each 3-feet in length. The bow section tapered in the lateral axis to a vertical stem. The sections were welded together and had a transverse bulkhead separating each section. The framing joining the two pontoons and supporting the deck structure was constructed of aluminum I-beams and the deck was a composite material with diamond tread.
- c) Embarkation/debarkation ladder. At the bow of the vessel a four step ladder was fitted for boarding and exiting the vessel. Also fitted to ladder was a handrail on either side of the stair treads. The stairs were constructed of a welded aluminum framing with aluminum diamond tread plate as the stair tread. Aluminum diamond tread plate was also fitted to either side of the ladder structure which partially enclosed the ladder framework.
- d) Deckhouse. The deckhouse of the *Lady D* was a fully enclosed structure constructed principally of 1-1/4 inch square aluminum tubing supporting a skin of 0.019-inch thick aluminum sheet metal. In addition, each of the four deckhouse bulkheads had glass windows, and the forward and aft bulkheads had doors. The forward bulkhead had a sliding glass door, and the aft bulkhead had a

swinging door with a glass light. The canopy, or overhead of the deckhouse, was constructed of 1-1/4 inch aluminum square tubing framework supporting a 0.019-inch thick aluminum sheet metal.

e) Outfitting. The vessel had two longitudinal benches located within the deckhouse. The benches were bolted to the diamond tread deck at the outboard sides of the deckhouse. Each of the benches was constructed of 1-1/4 inch aluminum square tubing and wooden planks. Each bench had two parallel horizontal surfaces created by the wooden planks: the top planks were used as a passenger seating surface and the lower plank was a life jacket storage shelf. Also located within the deckhouse was the operator station, which consisted of a console and swiveling padded chair. The console was fitted with the steering wheel, throttle and clutch controls, a marine VHF-FM radio, and an electrical switch and fuse panel.

f) Propulsion and steering system. The vessel was powered by a 90-HP, 4-stroke, Honda™ outboard engine. The engine throttle and clutch were controlled by independent levers mounted on the control console. Wire cables connected the throttle and clutch control levers to the engine. The vessel was fitted with two gasoline fuel tanks mounted at the stern of the vessel, on directly above each pontoon. The starboard tank was slightly larger than the port tank, and both tanks had a combined capacity of about 40 gallons. When the vessel was originally put into service, it had only a single fuel tank, and later the second fuel tank was fitted.

The steering system was a SeaStar™ hydraulic type system. The steering system consisted of an axial piston pump actuated by the helm (steering wheel) and an actuating cylinder connected to the engine. The pump and cylinder were connected to each other by hydraulic hose.

g) Electrical and communications system. The vessel was fitted with a 12-volt DC electrical system for engine starting, lighting, and radio power. The system had one battery fitted at the aft area of the deck, between the two fuel tanks. The electrical power was distributed to various loads through a switch and fuse panel mounted on the top surface of the operator's console. A battery disconnect switch was fitted near the battery. The vessel was fitted with a Standard Horizon Eclipse +™ VHF-FM marine radio. According to manufacturer's product literature, the radio was fitted with a NOAA weather alert feature³. The radio was mounted on the top surface of the operator's console.

3) Company maintenance program

a) According to the Director of Seaport Taxi,⁴ the operating company of the Lady D, the company had a preventive maintenance program that included a "feedback system," as described in more detail below. The maintenance program, however, was not formally documented by instructions, did not require periodic inspection and preventive maintenance of systems and equipment, and no records of maintenance and repair actions were maintained. In an interview, the Director of Seaport Taxi described the program as "a feedback system ... we look at the vessels .. they are very simple ... very few systems on the vessels." As part of the feedback system, the vessel masters are required to maintain a Captain's Shift Log on which they provide information for such line items as the time of day they began operating a particular vessel, how long they were on duty, and how much gas or engine oil they added during their shift. The log form also provides space where the masters can write comments about conditions or problems that they encounter during their shift such as vessel equipment that is damaged, missing, and/or not operating efficiently. At the end of their shifts, the masters submit the logs to the Seaport Taxi office. The office manager then reads the shift logs and provides a copy of any report of damage or of malfunctioning equipment to the fleet captain for review and/or action.

b) The director further described the vessel maintenance program as being "proactive." He said the captains are required to check all systems, lights, horns, and steering each time they are assigned to a vessel and to make sure everything is operating properly and to their satisfaction before they put the boat in service. The director stated that as licensed masters, he believed the captains "should have a

³ According to the company website, the ECLIPSE+ features 10 NOAA weather channels including weather alert allowing ECLIPSE+ to intercept frequency encoded regional Emergency Weather alerts.

⁴ Information about the company maintenance program was obtained primarily from the director of Seaport Taxi in an interview conducted on March 7 and 8, 2004.

good handle on what is right and proper for leaving the dock. The Seaport Taxi director stated that he believed the company's proactive method of working on the vessels ensures the safety of equipment and operations. He told Safety Board investigators, "My approach is let's not wait until the thing is a total wreck and have to fix ten things. Let's work on them as they occur. I find that you have less stress level built up, and the boats are maintained at a higher state."

c) According to the Director, National Historic Seaport of Baltimore, about 10 percent of the Seaport Taxi annual operating budget, or \$50,000-60,000, was spent on maintenance of the fleet.

d) Both the fleet captain and the Seaport Taxi director said that they periodically inspect each vessel and its components, in particular, the engine, engine parts, and boarding ladders. According to the fleet captain, each morning, before the masters report for work, he goes to the inspects the, making sure they are tied in properly, that plastic bags are not fouling the propellers, and that the engines do not show any indication of a problem. He also checks the ladders and examines the vessels to see whether the previous crews left the boats clean. After performing a visual check of each vessel, the fleet captain goes to the Seaport Taxi office and reads copies of the previous day's shift logs to see whether a master has reported a problem with the boat. The fleet captain said that he frequently operates a boat to oversee how the crews are handling their vessels and to check what the traffic is like. If a master has reported that a particular boat is not operating efficiently or correctly, the fleet captain said that he will take out that boat to determine whether he can identify and, if possible, correct the problem. If he or the Seaport Taxi director do not have the capability to fix the problem, they contract with local marine repair facilities to perform the work. On the days that the fleet captain does not work, the Seaport Taxi office manager provides the director with a copy of any captain's shift log indicating a problem with a vessel, and the director will look at the boat. Otherwise, the Seaport Taxi director does not have "a written schedule" for examining the vessels in his fleet. He said that during Seaport Taxi's slow season, which is winter, he spends more time on marketing and planning for the upcoming summer season. As activities accelerate, and "the boats are cycled and used more often," he shifts his focus from the office to waterway operations and examines and rides the boats more often.

e) The Seaport Taxi director and the fleet captain both indicated that they were last aboard the Lady D on March 2. The fleet captain was working with the crewman who would subsequently serve as the mate on the Lady D on the day of the accident. The fleet captain was overseeing preparations for the vessel's annual topside inspection by the Coast Guard, and the mate was counting and checking the condition of the preservers, testing the water lights, and going through the boat making sure everything was the way it should be. The Seaport Taxi director stopped by to check the progress of the preparations. He said that, at the time, there was "nothing wrong" with the vessel's mechanical operation and outfitting. The director indicated that the last time he operated the Lady D was February 25, when he took it to attend a meeting at the Constellation. He said, "As far as the operational systems, [the vessel] seemed fine. Radio was working." The fleet captain said that he operated the Lady D less than a week before the accident and noted no problems.

f) History of Fleet Maintenance. The Seaport Taxi director said that when he joined the company, in 2001, "We had a fleet that was in need of some attention. It had a breakdown rate that was pretty significant....It just wasn't a viable operation from any aspect." The Seaport Taxi director further explained that the company had inherited a fleet with different brands of motors with different horsepower and other mismatched items. He had worked to standardize the outboard configuration and, with the exception of the Lady D, had replaced the Honda motors on the boats with Mercury motors. The director said that the Honda motors were very susceptible to wearing out quickly because of the high number of shift cycles the vessel operators went through. The director indicated that he had replaced the vessels' single lever engine controls⁵ to dual lever controls "for reliability." He explained that with the number of shift cycles, "the...single lever control was wearing out too quickly and getting out of parameters, causing excessive wear issues on the rest of the power train." He stated, "I went with the stick control, which you engage yourself. The clutch is separately controlled from the throttle. When the power train was starting to get worn [on a vessel], we would replace it with an upgraded unit." Seaport Taxi found that, during

⁵ With a single lever control, where neutral, or idle, is in the middle, you push the lever forward to engage the engine and the further you push it forward, the greater it accelerates the boat. Reverse occurs when you pull the control lever back to the center [idle] and then you get reverse the same way with a mirror image.

docking, the front-loading pontoons suffered wear and damage requiring frequent repair and welding. The Seaport Taxi director subsequently developed a front bumper system that reduced front end abrasions and scuffing. In winter 2003, the company upgraded the cables and steering systems on the boats. The NHS director indicated that Seaport Taxi had made "tremendous...updates on the boats over the last 3 years." He said he was "very comfortable operationally with the engines, the steering, the cable, the really important stuff." According to Seaport Taxi's fleet captain, "If a boat goes down for any...period of time, it's because parts aren't available and/or we don't have the manpower resources to transport it to a service facility." The Seaport Taxi director said that he did not maintain any records of routine maintenance performed by Seaport Taxi personnel. However, bills from contractors for [drydock] repairs and examinations that necessitate removing a vessel from the water must be submitted on a purchase order to Living Classrooms for payment, meaning the accounting department of Seaport Taxi's parent company maintains documentation on more extensive maintenance.

g) Lady D's Maintenance. According to the director, when he joined Seaport Taxi, the company's folder on the Lady D contained several CG-835s, Notices of Merchant Marine Inspection Requirements, that had been issued by the Coast Guard for unacceptable deficiencies⁶ such as a cracked hold and cracked steps. He indicated that Seaport Taxi had improved the Lady D's current record, and that Coast Guard inspectors had not noted any unacceptable structural defects during the vessel's last annual examination [need to add date of exam].

h) According to Seaport Taxi's fleet captain, "The Lady D's always been...a preferred boat in the fleet. It's one of our smaller boats. It's an enclosed boat, so it's an all-weather vessel that is used 12 months out of the year. If it isn't operating efficiently, it gets fixed relatively quickly,...gets preferential treatment in repair and refit..." Officials indicated that the Lady D was the only vessel in the fleet with a four-stroke Honda. The Seaport Taxi director said, "The engine mount on the vessel constantly develops cracks that need to be attended to. The engine parts...crack...loosen up. [You] have to have it welded." As far as structural work, he indicated that the front deck had been reconstructed, reinforced and strengthened and that the pontoons had been welded and repaired. He stated that shortly before Hurricane Isabel, in September 2003, the motor had some cracked bolts and the engine was loose and sagging. Seaport Taxi had the motor replaced with a new Honda engine, which was "reinforced better than it was from the factory."

i) The Seaport Taxi director said that in summer 2003, there was a "little problem" with the Lady D's steering system; it was "a little notchy,⁷" but he greased all the points, which seemed to solve the problem. Since then, he had not received any reports about steering problems until about 3 or 4 weeks before the accident, when one captain submitted a log report complaining about "a little glitch in the steering." The director was greasing the [?tube?] when he noticed some salt had accumulated in it, whereupon he corrected the problem.

j) Shift Logs and Repair Orders. As noted earlier, Seaport Taxi requires its vessel operators to maintain a log documenting routine shift information and comments pertaining to conditions or problems during their shift. The Safety Board reviewed 153 Captain's Shift Logs representing 140 days of service for the Lady D (the No. 1 boat) between May 2003 and February 2004. The shift logs were prepared by several captains, including the master who later operated the Lady D on the day of the accident. Thirteen of the logs indicate either that repairs were made during the shift or that problems warranting repair were identified. In three instances, the captains themselves corrected minor problems, including replacing a burned out running light; removing a plastic bag that had fouled a propeller; and reconnecting a gas motor line that had become unattached.

k) On September 30, 2003, and February 29, 2004, two different captains noted that the VHF radio was not operating. On August 4, 2003, a captain wrote that the steering "is very difficult." On August 12, a different captain reported that after the Seaport Taxi director and the fleet captain had removed and straightened the propeller, "steering is still sticky." Later in August 2003, a captain reported that the

⁶ A "deficiency" is any failure to meet minimum requirements of vessel inspection laws.

⁷ Notchy means shifting through the gears is not smooth but feels as if you have notches that you have to move the lever past in order to make a complete transition from one gear to another.

starboard forward sliding window fell out before leaving dock; however, he was able to put it back in with a bungee cord underneath it. Three log forms in May 2003 indicate a repair order is attached; however, the nature of the problem is not identified, and Seaport Taxi did not include a copy of the repair order with the logs.

I) Seaport Taxi provided investigators with 11 bills submitted from contractors to Living Classrooms Foundation for various repairs made to the Lady D between November 8, 2000, and October 4, 2003. The following are excerpts from the repair bills:

Date	Work Order
November 2000	"Remove motor; put aside; Remove motor and install on another boat."
April 2001	"Haul, Powerwash, and Block"
May 2001	"Remove motor"
April 2001	"Repair front of boat for Coast Guard Inspection;" Weld steps
August 2001	Order for Top Mount Control; (Shift control head)
August 2001	"Haul out, wash, and inspect" (weld pontoon/repair)
April 2001	Haul out, rebuild front of deck; Rebuild, reinforce front pontoon sections; Rebuild, reinforce engine brackets; Rebuild, reinforce steps; Repair and pressure test rear pontoon sections; Test all compartments; Paint bottom
May 2002	Repaired damaged aluminum hull (on PO: Port aft pontoon section)
February 2003	Replaced motor with Honda engine; Repaired cabin damage, starboard side
September 2003	Shorthaul (prior to hurricane) Fix engine mount
October 2003	Haul out two boats [Nos. 1 and 11]; Rebuild/Reweld engine brackets

4) Damage

a) Damage to the vessel resulting from capsizing could not easily be distinguished from the damage that resulted from the recovery operation. Although the capsizing event likely did result in some damage to the vessel, the first responders inflicted additional damage to the vessel during the recovery effort. In an attempted to free trapped persons, the crew of the responding navy vessel lifted one side of the *Lady D* by positioning the LCM's bow gate under one of the *Lady D*'s pontoons. After the accident and subsequent recovery effort, the deckhouse was found to be completely detached from the vessel when it was righted the day following the accident. Some accident victims stated that in order to exit the vessel they had to open the sliding windows at the side of the deckhouse. With the exception of a section of the aft bulkhead of the deckhouse, none of the deckhouse was recovered after the accident. The section of the aft bulkhead of the deckhouse was found to be partially attached to the vessel's deck after the accident.

b) The NTSB engineering team performed full damage survey after the vessel had been up righted and transported to a local marina. The boat was hauled out of the water in order to facilitate doing a complete survey. The following damage was noted during the damage survey:⁸

- The deckhouse was completely detached from the vessel. A portion of the aft bulkhead consisting of the swinging door and two windows, was found to be attached to the vessel by a line that it had become entangled with. The canopy section of the deckhouse was located during sonar searches for victims, but it was not recovered from the water.
- The starboard passenger seating bench was completely detached from the deck and was not definitively located during sonar searches.
- The operators chair was nearly entirely detached from the mounting base and was tilted to the starboard side.
- The cover from the throttle / clutch control mechanism was missing.
- A dent and hole was in the starboard pontoon at its aft outboard side.
- The steering system was tested and found to operate satisfactorily.
- The engine was not test because it had been submerged in water for a number of hours. The VHF-FM radio was not tested because it too had been submerged in water for an extended period of time.

5) NTSB Stability Study

a) Following the accident a stability study was performed to evaluate the intact static and dynamic stability of the vessel.⁹ The study consisted of five tasks:

- Task 1: an assessment of the stability calculations for the LADY D and sister vessels performed to show compliance with U.S. Coast Guard passenger vessel stability regulations. A determination of the adequacy of relevant data to successfully complete a more rigorous analysis of the static and dynamic stability.
- Task 2: perform a static stability analysis of the LADY D at the time of the capsizing using current USCG regulations.
- Task 3: evaluate the dynamic effects of wind (steady state and gusting), passenger and crew loading and movement, wave action, and any other relevant conditions, and the interrelationships of these dynamic effects on the stability of the LADY D that may have contributed to her capsizing
- Task 4: prepare a 3-5 minute computer animation video showing capsizing event
- Task 5: examine the dynamic response of the vessel LADY D when loaded to its maximum safe number of passengers, as determined by applying current stability criteria under similar environmental conditions, to provide some measure of assurance that the static stability criteria provided in federal regulations is adequate.

b) The absence of reliable mass properties data for the LADY D made it necessary to calculate the vessel's weight and center of gravity. Because the owner or the shipbuilder could not provide engineering drawings and most of the vessel above the deck was not available, the vessel weights had to be estimated. In order to establish weight and center of gravity needed to perform the static stability analysis, the boat dimensions were collected with the vessel out of water and freeboards were measured

⁸ No attempt is made in this factual report to distinguish damage that resulted from the capsizing event from damage that resulted from the recovery operation because it could not factually be established when the noted damage had occurred.

⁹ The stability study was performed by John J McMillan Associates, Inc., under NTSB contract no. GS-23F-0068. The study was completed on Aug 27, 2004.

while the vessel was afloat. The vessel was floated in its damaged condition without adding any weights for the missing vessel components, such as the starboard seating bench or the deckhouse. Using GHS computer software, the static stability analysis performed on the *Lady D* (Task 2) showed that the vessel did not meet the current regulations of 46CFR 178.340 for pontoon vessels operating in protected waters with the 25 (140 lb) passengers shown on her stability letter issued on March 28, 1996. The vessel failed to meet the minimum criteria for adequate stability in both transverse and longitudinal directions.

c) Additional analysis was done for the vessel as it was actually loaded at the time of the accident, that is with an average passenger load of 168.4 lbs. As in the previous case where the vessel was loaded with 140 lb passengers, the vessel failed to meet the stability criteria. The righting arm curve for the vessel was shown to be approximately 0.73 feet at 11.3 degrees of heel.

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General HydroStatics

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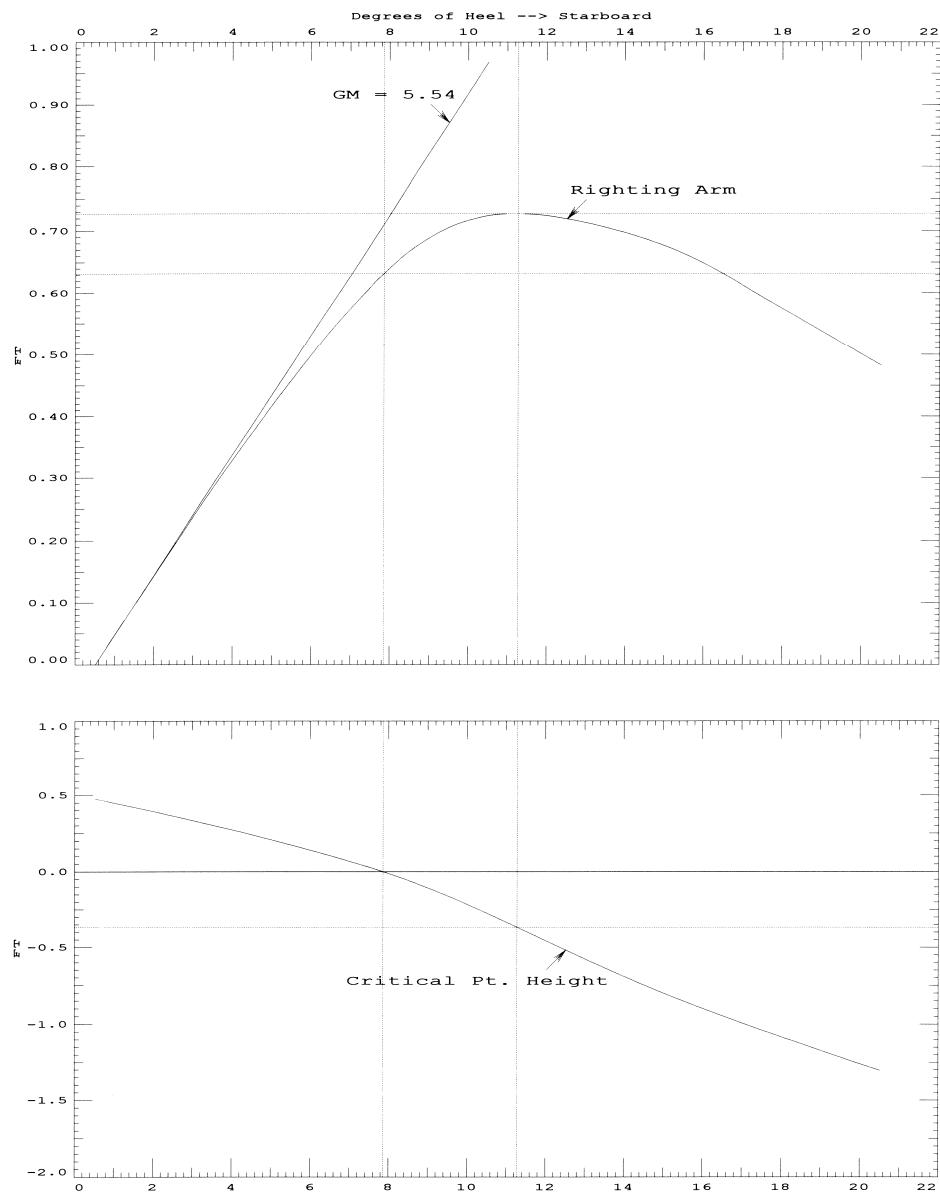


Figure 1 - Righting arm curve

d) Because the current stability regulations do not address the effects of wind on pontoon boats operating in protected waters,¹⁰ additional calculations were performed to evaluate the theoretical ability of the *Lady D* to withstand a 40-knot beam wind. The evaluation assumed that the vessel was loaded at the time of the accident using passenger weight gathered through witness interviews. The average passenger weight was calculated to be 168.4 pounds. In addition, assumptions had to be made regarding the vessel profile since the deckhouse was detached and was not recovered after the accident. The calculations showed that the vessel had adequate righting energy to resist the 40-knot wind acting on the directly on the side of the vessel. In the simulation, the vessel heeled to about 6 degrees, with slightly less than 2 inches of freeboard remaining, but remained upright. These calculations did not consider the dynamic effects of current, wind gusts, waves or the movement of passengers aboard the vessel.

e) To complete task 3, naval architecture software and analysis methods was used to simulate the dynamic effects of wind and wave at the time of the accident. The analysis showed that the conditions were sufficient to cause capsizing. The simulation assumed a 1.25 wave chop at a peak period of 3.0 seconds and a 25-knot steady wind gusting to 42-knots. The dynamic simulation was repeated 20 times and the vessel capsized in every case. The average time to capsize of 23.7 seconds and all simulations capsized within 1-minute. The assumed wind and wave conditions were based on witness interviews, metrological data, and photographs taken shortly before the accident.

f) Performance of task 5 required additional static stability analysis to determine the maximum safe passenger load. The static stability analysis showed that the maximum safe loading condition for the vessel was 14 persons based on USCG stability standards specified in 46 CFR 178.340. Dynamic testing with the 14-person load showed that the vessel could capsize if the port beam was exposed to wind and waves for a substantial period of time. When the beam was exposed for 30 minutes, the 14-passenger condition capsized in 9 of 40 cases. Of cases that capsized, the average time to capsize was 12 minutes 14 seconds. The fastest time was 1 minute 29 seconds.

6) USCG Stability Standards.

a) The *Lady D* was the fourth in a series of 36-ft long by 8-ft wide pontoon boats constructed between 1986 and 1996 for use as commercial small passenger vessels in the Baltimore Inner Harbor. The first vessel in the class, the *Fells Point Princess*, had its stability evaluated by the local Coast Guard and was certified for passenger service. In 1992, the vessel ownership changed and the new owner vessel made significant modifications to the superstructure. As a result of the modifications, the Coast Guard reevaluated the vessel's stability. The vessel was subjected to a simplified stability proof test that was conducted according to standards established by the Coast Guard and was witnessed by representatives of the local Coast Guard Officer in Charge of Marine Inspection (OCMI). Based on the results of the stability proof test, the Coast Guard issued a stability letter and certificate of inspection allowing 25 persons to be carried aboard the vessel. Subsequently, over a three-year period, Susquehanna Santee Boatworks constructed three boats of the same general size and configuration (*Raven*, *Lady D*, and *Misty Harbor II*), and in each case, the Coast Guard certified the maximum allowable number of persons that could be carried on board. However, the three subsequent vessels were not subjected to a stability proof test, but were granted sister vessel status to the *Fells Point Princess* and the requirement for a stability proof test was waived by the cognizant USCG marine safety office. Although the *Fells Point Princess* and the *Raven* were not identical in all respects, were not built by the same boat yard, and were not constructed within 2 years of each other, the *Raven* was granted sister vessel status to the *Fells Point Princess*. Subsequently, the *Lady D* and the *Misty Harbor* were allowed to carry the same number of persons as the *Fells Point Princess*. One notable difference that existed between the various sister vessels was the extent to which the deckhouses were enclosed—two vessels were fitted with glass windows (the *Lady D* and the *Misty Harbor II*), and the other two sister vessels (*Fells Point Princess* and *Raven*) had openings in the sides of the deckhouse with no windows installed. The Safety

¹⁰ According to USCG regulations 46 CFR 175.400, "Protected waters is a term used in connection with stability criteria and means sheltered waters presenting no special hazards such as most rivers, harbors, and lakes, and that is not determined to be exposed waters or partially protected waters by the cognizant OCMI."

Board contracted weight study performed on the *Lady D* estimated the weight of the windows and doors to be in excess of 400 lbs.¹¹

b) The *Lady D* was built in March 1996, and the Baltimore Coast Guard office also issued a stability letter in March 1996.¹² The stability letter stated that the *Lady D* had a sister vessel relationship to the *Raven*, and based on a simplified stability test conducted on the *Raven*,^{13 14} it was “deemed to have satisfactory stability for passenger service under reasonable operating conditions for the carriage of not more than 25 persons on protected waters.” Since the *Lady D*’s sister vessel had supposedly undergone a stability test, the requirement to conduct a stability test of the *Lady D* was waived by the USCG.^{15 16} However, the Coast Guard could not locate any documentation of a *Raven*’s stability test, and stated that a stability test had not actually been done on the *Raven*. In addition, the *Raven*’s stability letter stated “the stability of the *Raven* has been determined to be satisfactory based on its sistership relationship to the *Fells Point Princess*,” and that a stability test had been conducted on the *Fells Point Princess*.

c) The Coast Guard required that new small passenger vessels be subjected to a stability test when their stability was questioned by the local officer in charge of marine inspection. Regulations required that pontoon boats be subjected to a simplified stability proof test specified at 46 CFR 178.340. Alternatively, the owner could perform more detailed stability calculations specified in Subchapter S of USCG regulations specified at 46 CFR 170.170 (weather criteria), 46 CFR 173 (vessels of unusual proportion and form, a righting energy criteria), and 46 CFR 171.050 (passenger heeling criteria). However, failure of the proof test in 46 CFR 178.340 does not necessarily mean that the vessel lacks stability for the intended route, service, and operating condition, but that calculations or other methods must be used to evaluate the stability of the vessel (see 178.320(e)). Typically, unless the operator choose to reduce passenger capacity until the vessel passed the proof test, the stability standards in Subchapter S (170.170, 170.173, 171.050) are used to determine whether the vessel's stability is adequate.

d) According to the Coast Guard, the criteria for pontoon boat stability existed since the early 1990s in the USCG Marine Safety Manual as guidance. The existing standards listed at 46 CFR 178.34 were added to the regulations in 1996. Since the *Fells Point Princess*’ stability was evaluated by the USCG in 1992, the existing regulations had not yet been established for T-boats carrying 49 passengers or less. Determination of the adequacy of vessel’s stability for a specific route was left to the discretion of the local Officer in Charge of Marine Inspection (OCMI), and a stability test was not required. The OCM could assess the results of a simplified stability test under 49 CFR 170.030, a stability proof test for pontoon-type small passenger vessels according to guidance in the USCG Marine Safety Manual, calculations based on the manufacturer’s weight certificate per the Marine Safety Manual, a comparison to a sister vessel, a full stability analysis based on an inclining experiment, or any combination of these or other methods at the discretion of the OCMI. The OCMI in Baltimore subjected the *Fells Point Princess* to a simplified stability test, and according to the USCG, a procedural error was made in the conduct of the test. The *Fells Point Princess* was certified to carry more passengers than it should have been allowed had the test been properly performed. The worksheet for the stability test shows the weight shift made to

¹¹ JJMA report dated 27 August 2004, Appendix B - Weights

¹² The stability letter issued to the *Lady D* by the Baltimore USCG office is undated, but according to the vessel’s Certificate of Inspection, the stability letter was issued March 29, 1996.

¹³ According to the *Lady D*’s stability letter, the *Raven* stability test was conducted on November 29, 1992.

¹⁴ USCG Navigation and Vessel Inspection Circular No. 14-81 provides guidance on waiving of stability tests for “sister vessels.”

¹⁵ USCG regulations for inspected vessels at 46 CFR 170.175 state “The stability test may be dispensed with, or a deadweight survey may be substituted for the stability test, if the Coast Guard or the ABS has a record of, or is provided with, the approved results of a stability test of a sister vessel.

¹⁶ The USCG Marine Safety Manual provided guidance on when a vessel could be deemed to be a sister vessel. Chapter 6 D of the MSM (http://www.uscg.mil/hq/g-m/nmc/pubs/msm/v4/c6-sect_d.htm#d.2) – Stability Tests – states “The following general guidelines have been developed to provide guidance and to help keep the determination of “sister vessel” as uniform as possible: the previously inclined vessel and the proposed sister vessel should have been built within approximately 2 years from one another; the vessels must be built by the same shipyard; and the same basic drawings should have been used in the construction of both vessels.

cause heeling was Beam divided by 6 (8 feet divided by 6 = 1.33 feet) rather than the specified distance of Beam divided by 2 (8 feet divided by 2 = 4 feet). The mono-hull stability test required a weight shift of beam divided by 6. As a result of the stability test done on the *Fells Point Princess*, it was certified to carry 25 persons.

e) After the accident, in April 2004, the USCG performed a simplified stability proof test on the *Patricia P* (ex *Fells Point Princess*) in accordance with 46 CFR 178.340. The test determined that the vessel could be certified to carry 15 persons.¹⁷ The test involved the shifting of a simulated passenger load from the centerline of the vessel to the extreme outboard side of the vessel within the deckhouse. Subsequent to the test, the Coast Guard deactivated the vessel's Certificate of Inspection (COI) at the owner's request.

7) Average weight standards, early recommendation.

a) Noting that the average passenger weight of the passengers on board at the time of the accident (168.4 lbs) exceeded the average weight used in stability proof tests (140 lbs), that the traveling public has gotten heavier over the years, and that excess weight can negatively impact vessel stability, on Dec 20, 2004, the Safety Board issued a recommendation to the Coast Guard to address this issue. The recommendation asked the Coast Guard to revise its guidance to Officers in Charge, Marine Inspection, to determine the maximum occupant capacity of small passenger pontoon vessels either (1) by dividing the vessel's simplified stability proof test weight by the per-person weight allowance for an average adult stipulated in Federal Aviation Administration Advisory Circular 120-27D (174 pounds per person, assuming summer clothing and a 50-50 gender mix), or (2) by restricting (at the time of loading) the actual cumulative weight of passengers and crew to the vessel's simplified stability proof test weight.

b) In response to the Safety Board's recommendation, the Coast Guard stated that it partially concurred with the recommendation.¹⁸ It concurred with the premise behind option 1, that is, "that the standard weight per person needs to be updated to account for the increase in the average weight of Americans since 1960." However, the Coast Guard did not concur with the option 2 because the Coast Guard believes that typical operators of small passenger pontoon vessels do not have a means to accurately determine cumulative weight of passengers and crew at the time of loading. In their letter, the Coast Guard further stated that "the actions necessary to implement the a change to the standard weight per person used in simplified stability proof test for small passenger pontoon vessels go beyond a simple revision of guidance to Officers in Charge, Marine Inspection (OCMIs). The current weight standards are set out in regulation at 46 CFR 178.330 and extend to all other types of small passenger vessels as well. Therefore, any change would, and realistically should, affect all other small passenger vessel types." The Coast Guard has charted a workgroup to address this issue and they expected the workgroup to complete its work by May 1, 2005.

8) U.S. Coast Guard Stability Project

a) As a result of the accident, the Coast Guard initiated a project to identify all pontoon vessels in the various field units and to completely review the current stability standards for pontoon vessels, compare them to other standards and make recommendations for changes if needed. Coast Guard headquarters subsequently developed a 14-step action plan designed to evaluate and improve the current pontoon stability proof test process. The first step of the action plan was the issuance of a memorandum providing interim guidance addressing some of the field office concerns and questions. The guidance memorandum stated that the load weight allowance (140 pounds per person) was what was in the regulations; therefore, it was the standard that "we have to use." Coast Guard headquarters characterized the current simplified stability test for pontoons and other vessels as conservative and capable of accommodating heavier passengers. However, the Coast Guard did not indicate why or how the test calculations are considered conservative. On October 4, 2004, the Coast Guard Office of Compliance (G-MOC) issued Policy Letter 04-10 to the Officers-In-Charge, Marine Inspection (OCMIs) for evaluating stability and subdivision requirements of small passenger vessels inspected under 46 CFR

¹⁷ USCG Activities Baltimore - Activity Summary Report 2023457 details the results of the April 14, 2004 stability test.

¹⁸ Commandant USCG letter, dated Apr 7, 2005 and received by NTSB on May 02, 2005, serial no. 16732.

Subchapter T.¹⁹ Included with the guidance was a worksheet for Coast Guard inspectors to use when calculating stability proof tests for pontoon vessels operating on protected waters. The notes on the worksheet stated that, for purposes of testing, the weight per passenger equals 160 pounds, "except when passenger loads consist of men, women, and children." In such cases, the worksheet notes indicated that a weight per passenger of 140 pounds "may be used." The new job aid required that the inspector include a separate line item for the weight of crewmembers, with the crew test weight equal to 160 pounds per person. The worksheet also required the inspector to consider the effects of wind on the vessel hull that the passenger weight moment be greater than a minimum wind moment equal to 300 times the vessel length.



Thomas K. Roth-Roffy, P.E.
Engineering Group Chairman

¹⁹ The policy letter is posted at the USCG website, URL: <http://www.uscg.mil/hq/g-m/moc/Pol0410.pdf>